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Potential contribution of bioethanol fuel to the transport sector of Vojvodina

Siniša N. Dodić *, Stevan D. Popov, Jelena M. Dodić, Jovana A. Ranković, Zoltan Z. Zavargo

Department of Biotechnology and Pharmaceutical Engineering, Faculty of Technology, University of Novi Sad, Novi Sad 21000, Vojvodina, Serbia

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ABSTRACT

The Autonomous Province of Vojvodina is an Autonomous Province in Serbia and it is an energy-deficient country. The indigenous reserves of oil and gas are limited and the country is heavily dependent on the import of oil. The oil import bill is a serious strain on the country's economy and has been deteriorating the balance of payments situation. The country has become increasingly more dependent on fossil fuels and its energy security hangs on the fragile supply of imported oil that is subject to disruptions and price volatility. The transport sector has a 26% share in the total commercial energy consumption in Vojvodina. About 0.62 million tons of gasoline were consumed by this sector in 2008. Gasoline consumption in the transport sector is also a major source of environmental degradation especially in urban areas. Consequently, Vojvodina needs to develop indigenous, environment-friendly energy resources, such as bioethanol, to meet its transport sector's energy needs. Vojvodina produces about 3 million tons of sugar beet every year. There is a vast potential for bioethanol production from molasses of sugar beet in the country. Bioethanol can be used in transport sector after blending with gasoline, in order to minimize gasoline consumption and associated economical and environmental impacts. This paper presents the assessment of the potential contribution of bioethanol in the transport sector of Vojvodina. It is concluded that 20% of annual gasoline consumption in transport sector could be met from ethanol by the year 2026.

Contents

1. Introduction

The Autonomous Province of Vojvodina is an Autonomous Province in Serbia, containing about 27% of its total population according to the 2002 census. It is located in the northern part of the country, in the Pannonia plain. Vojvodina is an energy-deficient province. The indigenous reserves of oil and gas are limited and the country is heavily dependent on the import of oil. The oil import bill is a serious strain on the country's economy and has been deteriorating the balance of payment situation. The country has become increasingly more dependent on fossil fuels and its energy security hangs on the fragile supply of imported oil that is subject to disruptions and price volatility [1–3].

Transport system is an important element of the enabling environment for economic growth. Regions with adequate means of transportation have grown economically and those lacking in this vital field have historically lagged behind. In Vojvodina, the transport system consists of roads and railways transport services. Among these, road transportation is not only the most popular and

* Corresponding author at: Faculty of Technology, Bul. cara Lazara 1, 21000 Novi Sad, Vojvodina, Serbia.
E-mail address: dod@uns.ns.ac.yu (S.N. Dodić).

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widely used; it is also the only mode, which is available to most of the population. Road transport is a backbone of Vojvodina's transport system. The road traffic – both passenger and freight – has grown much faster than the country's economy [4,5].

The consumption of fossil fuels in the transport sector is a major source of environmental pollution in the country. Air pollution from the use of gasoline and diesel oil in the transportation vehicles is increasing with the increasing number of vehicles. Most motorcycles and rickshaws, due to their two-stroke engines, are the most inefficient in burning gasoline fuel and contribute most to emissions. This is adversely affecting the quality of air, especially in the metropolitan areas.

Air pollution, as global problem of the whole mankind, provoked programmed and systematical investigations of air in the area of Vojvodina, which was oriented to the following of trends of contents of specific polluters, estimation of effects of the polluted air on health aspects of population, nature and material resources, introduction of the preventive measures, informing of publicity and increasing of the level of consciousness of population [6]. In the region of Vojvodina, systematic measurements of emitting of general and of specific polluters, quality of air in many settlements is followed. The average yearly concentration of CO in air of the capital city of Vojvodina, in the centre of Novi Sad, is 0.19 mg/m^3, and its highest concentration reaches even 3 mg/m^3. Maximal lead content is 0.45 $\mu g/m^3$, while yearly average was 0.3 $\mu g/m^3$. Annual average concentration of SO_2 is 8 $\mu g/m^3$, and that of NO_2 10 $\mu g/m^3$. These data once more confirm fact that the transportation represents the extremely potent air polluter and source of emissions of harmful gasses [7,8].

In May 2000 the European Commission presented a proposal for a directive on the promotion of electricity from renewable energy sources in the internal electricity market, setting out targets for member states on generation of electricity from renewable energy sources as a proportion of gross electricity consumption by 2010. In order to promote the use of renewable energy, the Commission adopted the "Green Paper" [9].

In the area of the common agricultural policy and the rural development policy, Agenda 2000 [10,11] invites member states to encourage renewable energy sources. Biomass, in particular, must be developed by all available agricultural, fiscal and industrial means. The key recommendation of the European Conference on Renewable Energy was that the European Union should set a new medium-term target: renewable sources should satisfy at least 20% of energy consumption by 2020. For example, despite the broad potential for biomass in Spain the resources are underused and biomass energy therefore offers a magnificent development opportunity which should be encouraged in coming years. In this way it is hoped that electricity self-sufficiency can be achieved by 2010, 51% of which will come from wind power, with a saving of 4000 ktons in primary energy, and avoiding emissions of about 12 million tons of CO_2 per year [12].

Consequently, Vojvodina needs to develop indigenous, renewable and environment-friendly fuels to meet its transport sector are growing energy needs. Ethanol (bioethanol) is one such fuel. There is a vast potential for bioethanol production from molasses of sugar beet in the country [13]. Industrial bioethanol is produced through fermentation of molasses and subsequent distillation. It is then converted into fuel bioethanol through molecular sieve technology. Fuel bioethanol can be used in transport sector as pure bioethanol or after blending with gasoline (gasol). Bioethanol has a calorific value of 29.6 MJ/kg. The comparison of energy content of different fuels is shown in Table 1.

Table 1
Comparison of energy content of different fuels.

Fuel	Energy content (MJ/kg)
Gasoline	46.4
Diesel	45.6
Bioethanol	29.6
Methanol	19.7

This paper presents an overview of fuel consumption patterns and the potential contribution of fuel bioethanol in meeting the energy needs of the transport sector of Vojvodina.

2. Energy consumption patterns in the transport sector of Vojvodina

Transport sector is one of the major consumers of commercial energy in Vojvodina. The share of transport fuel in total final commercial energy consumption has 26.2% in 2007.

Crude oil production in Vojvodina in the year of 2008 amounted to 0.636 million of tons, what was insignifficantly less than in the year of 2007 (0.647 million tons). Total importation of oil and oil derivatives for the needs of Vojvodina in 2008 was 0.881 million tons, what is for 2.3% less if compred with the year 2007 (0.915 million tons). Total assured quantity of domestic and imported crude oil and of imported oil derivatives for Vojvodina's needs in the year of 2008 amounts to 1.562 million tons, what is for 2.4% less than in the year 2007 (1.617 million tons). Processing of the crude oil and finishing of semi-finished products for the year of 2008 amounts 3.452 million tons, what is for about 1.7% than in the year 2007 (3.546 million tons). Of the total quantity of oil derivatives, which are obtained in oil refineries in Vojvodina, in Vojvodina are consumed some 43%. Projected consumption of oil derivatives in the year 2008 amounts to 1.511 million tons, what is for 3.1% more than in the year 2007 (1.528 million tons). Consumption of the oil derivatives as the transportation fuels in the year 2008 amounts to 0.620 million tons, what is for about 2.4% higher than in the year 2007.

It is realistic to expect that the production of oil would be kept on the current level for the prolonged period of time. The largest part of the domestic oil stems from geological reserves of oil and gas in Vojvodina, which contribute with some 90% of the total countrysupstrat reserves. The needs of the crude oil are considerably higher than the domestic reserves, and it can be expected in the future period that the differences between the produced and the necessary quantities of the oil in the country will be even more and more greater. This problem is resolved with imports of oil and, to some degree, with the exploitation of oil wells situated abroad. Differently from the exploitation of the domestic emplacements, whose level stagnates, foreign oil exploitation grows from 1 year to another, so that the domestic production is even more and more supplemented [14].

Projection of the needs of motor gasoline in Vojvodina till the year 2026 is outlined in Table 2. The needs for motor gasoline have special importance, as its substitution with bioethanol can be predicted. Projection of gasoline need in subsequent years indicate the evident increase, so that the discovering of alternative energy resources obtains high signifficance.

3. Potentials of fuel bioethanol production in Vojvodina

Economy of Vojvodina is largely based on developed food industry and fertile agricultural soil that makes up to 84% of its territory. About 70% of agricultural products is corn, 20% industrial herbs, and 10% other agricultural cultures. Other branches of industry are also developed, such as metal industry, chemical industry, electrical industry, oil industry, construction industry, etc. Sugar beet is one of the major crops of the country.

Besides to raw materials shown in Table 3 that can be classified as already conventional raw materials for the bioethanol production, significant are also the non-conventional raw materials that

Table 2
Needs of motor gasoline in the period 2005–2006.

Year	Motor gasoline (tons)
2005	670,000
2007	704,000
2008	722,000
2010	758,000
2012	800,000
2015	840,000
2026	1,165,000

Table 3
Average yields of agricultural crops in Vojvodina and potential bioethanol yields.

Raw material	Yield (tons/km^2)	Bioethanol yield with respect to the raw material (L/tons)
Sugar beet	3400–4500	80
Corn	4500–6500	350
Wheat	300–500	370

Table 4
Average yields of bioethanol from waste products and by-products from industry and agriculture of Vojvodina.

Raw material	Bioethanol yield (L/tons)
Sugar cane molasses	250–330
Sugar beet molasses	260–310
Whey (sweet)	020
Sulphite lye (larch)	1
Wood	200
Straw	170
Corn stalks	160

include by-products and wastes of different industries, as well as the agricultural wastes. These raw materials, together with average obtainable bioethanol yields, are shown in Table 4. These raw materials are mostly based on cellulose and hemicelluloses, or on sugar components (sugar beet and sugar cane molasses). It should be stressed out that the raw materials based on cellulose and hemicelluloses, although to smaller extent applied on the industrial scale, are now considered as the prospective raw materials for bioethanol production. At the contemporary level of technology development, conversions of these raw materials into fermentable sugars are low and the processes are economically inconvenient, but for their low prices and high accessibility, today exist large R&D efforts and high investments into such technologies introduction.

Of the raw materials shown in Table 4, for Vojvodina the most significant is sugar beet molasses, although the fact that sugar industry shows trends for even higher exhaust of sugars from molasses, while sugar content in molasses in sugar industry can be seen as pure losses. Fermentation industries prefer molasses that are rich in fermentable components, first of all sucrose. The most significant agricultural raw materials for bioethanol in Vojvodina are sugar beet, wheat and corn.

Of the total available area of Vojvodina that amounts to 21,533 km^2, 73% (15,819 km^2) are aril soils, which in the year 2005 enabled production of 1,107,275 tons of wheat, 4,215,117 tons of corn and 2,966,316 tons of sugar beet. Compared with annual production of other agricultural cultures that represent potential biomass for fermentation into bioethanol in Vojvodina, corn is considered to be the mostly grown and exported raw material, as it can be concluded from Table 5 [14].

Today, bioethanol production on Vojvodina is performed in six industrial plants with total annual production of about 22,000 tons. All these plants perform production of bioethanol with maximal ethanol content of 95% by volume, which is mainly used for strong alcoholic drinks, and to less degree for medical of pharmaceutical purposes. Bioethanol production in Vojvodina started significantly to decrease or to stagnate in the period of 1991 till 2000, after which, after the prolonged period of crisis, it started to recover and to increase. Production in 2005 was for almost 4% higher than in the precedent year. In spite to that, the realized production of bioethanol in Vojvodina in the year 2005 fulfilled not the domestic need, so that bioethanol imports were recorded [15].

Table 5
Produced, exported and imported quantities of wheat, corn and sugar beet in the year 2005.

Raw material	Production	Export	Import
Wheat (tons)	1,107,275	141,680	0
Corn (tons)	4,215,117	806,010	162
Sugar beet (tons)	2,966,316	236,150[a]	53,971[a]
		61,543[b]	40[b]

[a] Refined sugar.
[b] Molasses.

4. Benefits of bioethanol use in the transport sector

The use of bioethanol as transport fuel has many advantages. The blending of bioethanol with gasoline will reduce the gasoline import and the corresponding import bill. The use of indigenous fuel guarantees a certain degree of security of energy supply. The addition of bioethanol to petrol enhances the octane value and thereby improves the efficiency of the engine. Bioethanol has a lower vapor pressure than gasoline, which results in lower evaporative emissions. Bioethanol flammability in air is also much lower than that of gasoline, which reduces the number and severity of vehicle fires. Burned in internal combustion engines, bioethanol fuel releases less CO and SO_2 emissions than gasoline and diesel fuels. Bioethanol use as a transport fuel realizes a greenhouse benefit.

Bioethanol production from molasses will boost employment for neighboring populations. Implementation of bioethanol production from molasses will bring additional revenue to the sugar industry, which is facing threats of price and quota reduction in the preferential markets in the context of trade liberalization.

5. Potential contribution of fuel bioethanol in meeting of future energy demand in the transport sector of Vojvodina

As described earlier, fuel bioethanol can be used in the transport sector as pure fuel or after blending with gasoline. A blend of bioethanol and gasoline (ratio of 10:90 or 20:80) is acceptable for use as motor fuel. No change in car engine is required for a 10% blend. Substitution of petroleum by ethanol as a motor fuel has already gained universal recognition. Several countries of the world have successfully developed their fuel bioethanol program. US, India, Brazil and European Union have used the bioethanol fuel in aircrafts, automobiles, trucks and tractors. Currently, almost all of the vehicles manufactured in Brazil have been fitted with flex fuel engines. These vehicles are working well and have no obvious environmental consequences [16].

5.1. Methodology and results

As the basis for calculations, data on consumption and projected needs of motor gasoline in Vojvodina in the period till 2006 were taken. Based on these data, minimal quantities of bioethanol that are necessary for motor gasoline substitution that were prescribed with EU Directive on Motor Fuels 2003/30/EC were calculated, and the results are outlined in Table 6.

Table 6
Projections of bioethanol consumption in the transport sector of Vojvodina.

	Year				
	2005	2010	2012	2015	2026
Motor gasoline (tons)	670,000	758,000	800,000	840,000	1,165,000
EU Directive 2003/30/EC (% of substitution)	2%	5.75%	–	–	At least 20%
Necessary quantity of bioethanol (tons)	13,400	43,585	56,215	85,214	233,000

From Table 6 it is possible to see that, with presumption that Vojvodina, i.e. Serbia, obeyed European Directive on Biofuels 2003/30/EC and introduced minimal substitution of 2% of motor gasoline with ethanol already in the year 2005, necessities of bioethanol for fuel purposes would be 13,400 tons. In such a way, total needs of bioethanol in that year for fuel and for strong alcoholic drinks could amount to 65,400 tons, which was three times larger than the production in that year, which was about 220,000 tons, and 2 times larger than the maximal existing capacities. In the year 2010 needs of bioethanol in Vojvodina would be even significantly higher, as it is estimated that for the minimal prescribed substitution of motor gasoline with bioethanol of 5.75% it would be necessary to produce 43,585 tons of bioethanol. In such case, even if necessities for bioethanol for industrial purposes, pharmaceutical purposes and strong drinks remained unchanged (52,000 tons), total needs of bioethanol would amounts at least 95,585 tons, what is 4.5 times higher if compared with the existing production, or 3 times higher if compared with the highest possible existing capacity.

Up to the year 2026, needs for bioethanol in Vojvodina will have further trend of increase, as it can be estimated that, for the least prescribed substitution of motor gasoline with bioethanol of 20% (till the year 2020), it would be necessary to produce some 233,000 tons of bioethanol. In such a case, even if the needs for bioethanol for industrial and pharmaceutical purposes and for alcoholic drinks remain unchanged (52,000 tons), total needs of bioethanol would reach 285,000 tons, what is almost 13 times more if compared with the contemporary production.

6. Conclusion

The transport sector is one of the major consumers of commercial energy in Vojvodina. Oil is the main fuel used in this sector. Oil is an imported commodity and is also not environment-friendly. There is substantial potential of bioethanol fuel production from molasses in the country. Bioethanol, an indigenous, renewable and environment-friendly fuel, can be used as pure fuel or after blending with gasoline in the transport sector. The consumption of bioethanol fuel is projected to be 0.233 million tons by the year 2026.

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